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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 958

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. ▼ August 22, 1921

DEVELOPMENT OF TUBERS IN THE POTATO.

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CONTENTS.

	Page.		Page.
Scope of the experiments	1	Details of the experiments	4
Work of previous investigators	1	Summary	25
Description of the tuber-bearing parts	4	Literature cited	27

SCOPE OF THE EXPERIMENTS.

The conditions which attend the setting and subsequent development of the tubers of the potato (*Solanum tuberosum* L.) are of interest not only to the plant physiologist but also to the practical grower, as a knowledge of the relation of these factors to crop production may, to a certain extent, be put to practical use.

The experiments described in the following pages were conducted at the Colorado Potato Experiment Station, Greeley, Colo., during the seasons of 1916, 1917, and 1918. A few minor observations were also made in Maine in 1919 for the purpose of verifying the conclusions previously reached relating to the time of the beginning of tuber formation.

While these studies could profitably be extended to cover a longer period and include a greater number of varieties and a wider range of environmental conditions, it is deemed advisable to place on record the results obtained up to the present time, since these lines of investigation have been temporarily suspended.

WORK OF PREVIOUS INVESTIGATORS.

While very extensive studies of the potato plant have been made, the development of tubers has received comparatively little attention. Jones and Orton (5, p. 155–156)[1] report results obtained

[1] The serial numbers in parentheses refer to "Literature cited" at the end of this bulletin.

with the White Star variety in 1893, harvested at 10-day periods from August 2 to September 22, and with the White Star and Delaware varieties in 1898, harvested at the same intervals from August 4 to October 6. There was found to be an increase in yield up to the time of the last harvest. A considerable part of the yield of tubers of marketable size developed after the 1st of September.

Kohler (7, p. 109–111), in experiments with the Early Ohio variety in 1909, by digging tubers at 7-day intervals from July 31 to August 30 obtained an increase in weight at the rate of 7.18 bushels per acre each day. The gain was also found to be very uniform throughout the period, with the exception of a slight drop at its end, which was attributed to the loss of foliage as the result of disease.

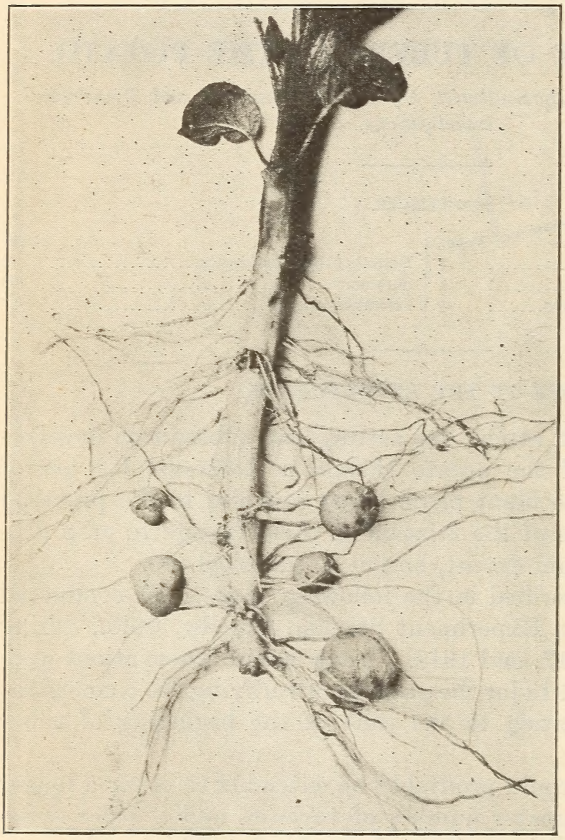

FIG. 1.—Plant of the Irish Cobbler variety of potato, showing the tubers borne on short stolons.

Werner (11, p. 20–21) in 1917 found that tubers of the Green Mountain variety harvested August 10, 20, 30, and September 8 and 11 showed daily increases of 2.34 bushels per acre during the first 10-day interval, while the increases for the last 3-day period were at the rate of 5.27 bushels.

Wilfarth, Römer, and Wimmer (12) found, in both field and pot experiments with the Geheimrat Theil variety, a fairly constant rate of increase in the weight of tubers during the four periods of growth which were studied. Analyses showed comparatively small changes in the percentages of the mineral constituents throughout the season, though there was a slight trend toward a decrease until the fourth period, when a very small increase was indicated.

Experiments conducted in boxes with the Up-to-Date variety, by Ramsay and Robertson (9), where four harvests were made at inter-

vals of approximately one month each, beginning one month after germination, showed that tuber development continued during the entire period, though the rate of increase was diminished during the fourth month. Analyses of the tubers harvested at the end of each monthly period showed that with respect to the mineral constituents there was little change in composition after the first month. Those produced during the first period, however, contained slightly higher percentages of these constituents than were found in the later harvests.

Chemical studies by Jones and White (4) with the Delaware and White Star varieties, dug at intervals of 10 days from August 4 to November 3, 1898, and from August 12 to October 11, 1899, showed that the most important changes occurring during the period of the experiment were those of yield rather than composition. There was, however, a very small decrease in the percentage of dry matter and nitrogen-free extract and a slight trend toward an increase in the protein, ash, and crude fiber as the crop approached maturity.

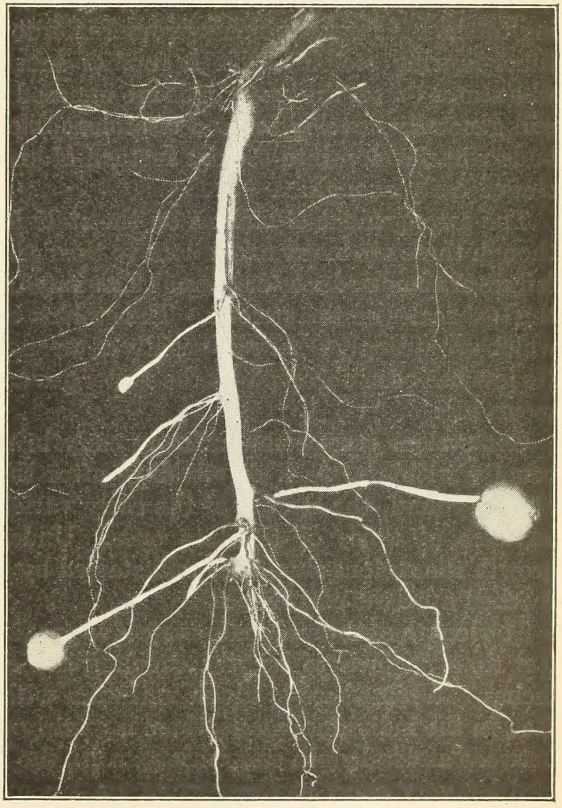

FIG. 2.—Plant of the Charles Downing variety of potato, showing the relatively long stolons on which the tubers are borne.

Studies of the composition of tubers before and after growth had ceased led Prunet (8) to conclude that during the period of growth the nutritive substances are uniformly distributed throughout the tuber, but after full size has been reached there is a movement of these substances toward the vicinity of the apical buds.

Data regarding the growth of tubers after frost were obtained by Follstad (1), who weighed one tuber from each of four hills on September 13, 16, 20, and 27, weighing the same tubers on each of the different dates without detaching them from the stolons. The leaves had previously been killed by frost on September 10. The

results showed an average gain in weight after the death of the foliage of 26.4 per cent, or 57 bushels per acre.

DESCRIPTION OF THE TUBER-BEARING PARTS.

The tubers are borne on underground stems, commonly called stolons, which are modified branches arising from the nodes of the main stem and situated below ground. The development of the buds into stolons rather than leaf-bearing branches depends largely upon certain definite environmental conditions, chief among which is the exclusion of light. De Vries (10) maintains that each axillary bud of the stem of a potato plant has the capability of developing, according to the conditions which surround it, into either a leafy stem or a tuber-bearing stolon. This is further substantiated by Franz (2), who states that if the lower buds are exposed to the light green shoots will generally develop instead of stolons, likewise the upper axillary buds will develop into stolons instead of green shoots if light is excluded early enough.

The arrangement of stolons on the stalk is in general five ranked, though there are many exceptions to this, which are attributed to the failure of some nodes to develop. This same arrangement occurs with the leaf scales on the stolons. The stolons terminate with leaf scales which are strongly recurved, usually at an angle between 90° and 180°. No law has been observed by the writer governing the direction of the recurving.

The stolons start comparatively early in the growth of the plant, usually within a week or ten days after the plants have appeared above ground, the stolons of the early varieties appearing a little in advance of those of the late ones. Under normal conditions of growth the stolons should be well started by the time the plants have reached a height of 4 inches.

The length of the stolons is subject to great variations, ranging from less than an inch to lengths equaling or occasionally exceeding 18 inches. While there is much variation within the variety, and, in fact, in the individual plant, there is a fairly well-defined relationship between stolon length and variety, e. g., the Early Ohio is characterized by very short stolons, while, on the other hand, varieties are occasionally found in which the stolons extend over such a wide area as greatly to increase the work of digging. (Figs. 1 and 2.)

DETAILS OF THE EXPERIMENTS.

EXPERIMENTAL METHODS.

The material used for the experimental work was grown under field conditions, the cultural practices employed following those in general use in the locality in which the work was done. The digging operations were performed by hand, special care being taken to get

all the tubers in each hill. The minimum size of tuber saved was one-half inch. Where a separation was made into marketable potatoes and culls the division was by weight, the marketable tubers including those equaling or exceeding 3 ounces (above 85 grams), and the culls, those below this limit.

THE FORMATION OF TUBERS.

Tuber formation begins, in general, at about the end of the period of flower-bud development, though this is not in all cases an exact criterion. In the early varieties the tubers invariably start to form by the time the buds are fully developed, while in the late varieties evidences of tuber formation may not be found until the buds have started to open. The Green Mountain variety appears to be exceptionally late in this respect, observations having shown that, in Maine at least, the formation of tubers did not start until considerable bloom was in evidence.

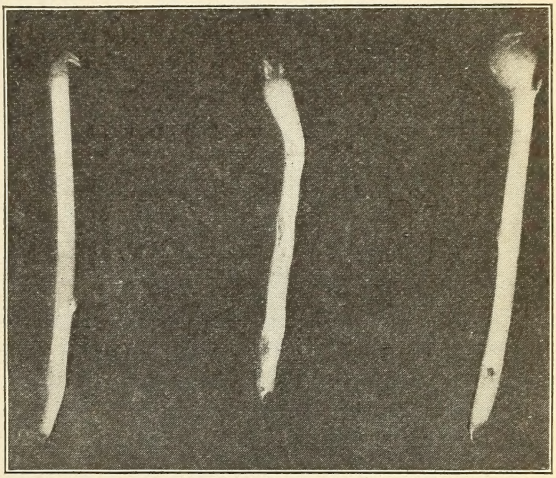

FIG. 3.—Ends of stolons of the Pearl variety of potato, showing different stages in the beginning of tuber formation. Left, stolon before tuber formation has started; center, swelling of the end of the stolon, which is the first stage in the formation of the young tuber; right, a later stage, showing the globular-shaped tuber.

The first indications of tuber formation are seen in the swelling of certain localized portions of the stolons. With very few exceptions these enlargements occur only at the ends of the stolons or, if the stolons are branched, at the ends of the branches. At first the swelling assumes a clavate shape but soon becomes globular, and as further development takes place the growing tuber assumes the characteristic shape of the variety. (Figs. 3 to 6.) According to Jurgens (6) the form of the tuber is governed by the relation of the length growth to the thickness growth.

Statistical studies.—To determine the rate of growth of the tubers, 200 hills of the Rural New Yorker variety were dug at 1-week intervals in 1916 and 1917, beginning soon after tuber formation had started and continuing until after the vines had been completely killed by frost. The records of the weight and number of tubers were obtained for each hill. In 1917 additional data were obtained from the same material by putting together all the tubers after the weighing of the

individual hills had been completed and dividing the population into 25-gram classes.[2] The results are shown in Tables I, II, and III.

TABLE I.—*Rate of development of potato tubers at Greeley, Colo., in 1916 and 1917.*

[Data from 200 hills of the Rural New Yorker variety dug at 1-week intervals during each season.]

Date of digging.	Time after planting (days).	Number of tubers.		Marketable tubers (per cent).		Weight (grams).					
						Total.	Average.		Largest—		Increase per hill.
		Total.	Average per hill.	Number.	Weight.		Per tuber.	Per hill.	Tuber.	Hill.	
Season of 1916:											
Aug. 24	72	1,085	5.4	2.4	7.1	37,235	34.3	186.2	160	418	.....
Aug. 31	79	1,151	5.8	34.8	61.2	79,028	68.7	395.1	299	856	208.9
Sept. 7	86	1,220	6.1	49.6	80.1	114,351	93.7	571.8	417	1,135	176.7
Sept. 14	93	1,169	5.8	65.3	91.7	150,987	129.2	754.9	715	1,449	183.1
Sept. 21	100	1,295	6.5	66.4	91.7	179,480	138.6	897.4	631	1,861	142.5
Sept. 28	107	1,125	5.6	71.4	94.1	193,637	172.1	968.2	852	1,826	70.8
Oct. 5	114	1,048	5.2	75.5	95.4	197,123	188.1	985.6	853	2,079	17.4
Season of 1917:											
Aug. 16	64	863	4.32	0	0	10,843	12.6	54.2	55	142	.....
Aug. 23	71	870	4.35	5.2	14.7	31,579	36.3	157.9	180	366	103.7
Aug. 30	78	922	4.61	33.2	60.2	65,064	70.6	325.3	255	670	167.4
Sept. 6	85	957	4.79	59.9	87.0	107,746	112.6	538.7	409	1,105	213.4
Sept. 13	92	960	4.80	70.0	95.7	142,470	148.4	712.4	735	1,480	173.7
Sept. 20	99	987	4.94	69.1	96.2	162,745	164.9	813.7	582	1,745	101.3
Sept. 27	106	928	4.64	73.5	97.3	186,460	200.9	932.3	815	2,270	118.6
Oct. 4	113	984	4.92	74.1	97.0	218,035	221.6	1,090.2	903	2,100	157.9
Oct. 11	120	935	4.68	79.4	97.6	222,055	237.5	1,110.3	991	2,280	20.1
Oct. 18	127	931	4.66	79.7	97.7	228,755	245.7	1,143.8	875	2,020	33.5

A study of the data presented in Table I brings out many points of interest. It will be seen that practically the entire crop of tubers was set at the beginning of the period of tuber development, probably within the space of a very few days. The data, however, show a slight increase in the number of tubers up to and including the third digging, in September; also a decrease after that period, so that the numbers at the beginning and at the end of the sampling period are very nearly the same. A possible explanation of this fluctuation is that the numbers employed may not have been large enough to eliminate the so-called experimental error. On the other hand, it seems quite probable that the small increases indicated in the records as occurring early in the season were actual. Toward the end of both seasons it was observed while digging the hills for the statistical studies that some of the very small tubers slightly below half an inch in diameter had shrunk considerably, and occasional evidences of the almost complete disintegration of these small sizes were found. If this condition occurred in tubers originally above the half-inch size, which would have been saved and counted at the earlier dates of sampling, it would account for the apparent decrease in the number of tubers toward the end of the season. Further studies are needed to determine whether this is the cause.

In both years there was an increase in the weight per hill and in the average weight per tuber throughout the entire period of the

[2] Twenty-five grams are about equivalent to 0.88 ounce avoirdupois.

investigation. In 1916 the percentage of marketable tubers with respect to both number and weight increased up to the end of the season, while in 1917 the number percentage remained nearly constant after October 11 and the weight percentage after September 27.

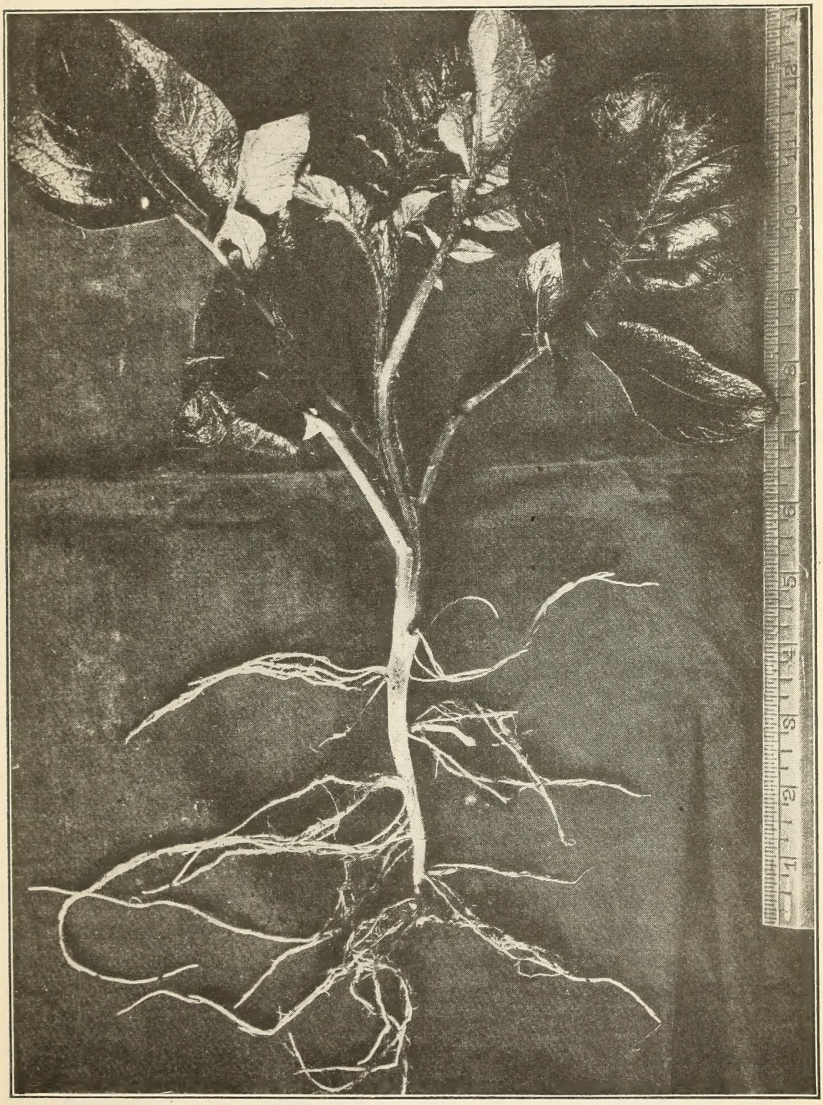

FIG. 4.—Young plant of the Irish Cobbler variety of potato, showing its root system and the starting of stolons. The plants shown in figures 4 to 6 were grown by and photographed under the direction of W. V. Shear.

The rate of growth was found to be very rapid during the early part of the period of tuber development. The largest increases per week (208.9 and 213.4 grams in 1916 and 1917, respectively) were at the rate of approximately 30 grams (1 ounce) per hill for each day.

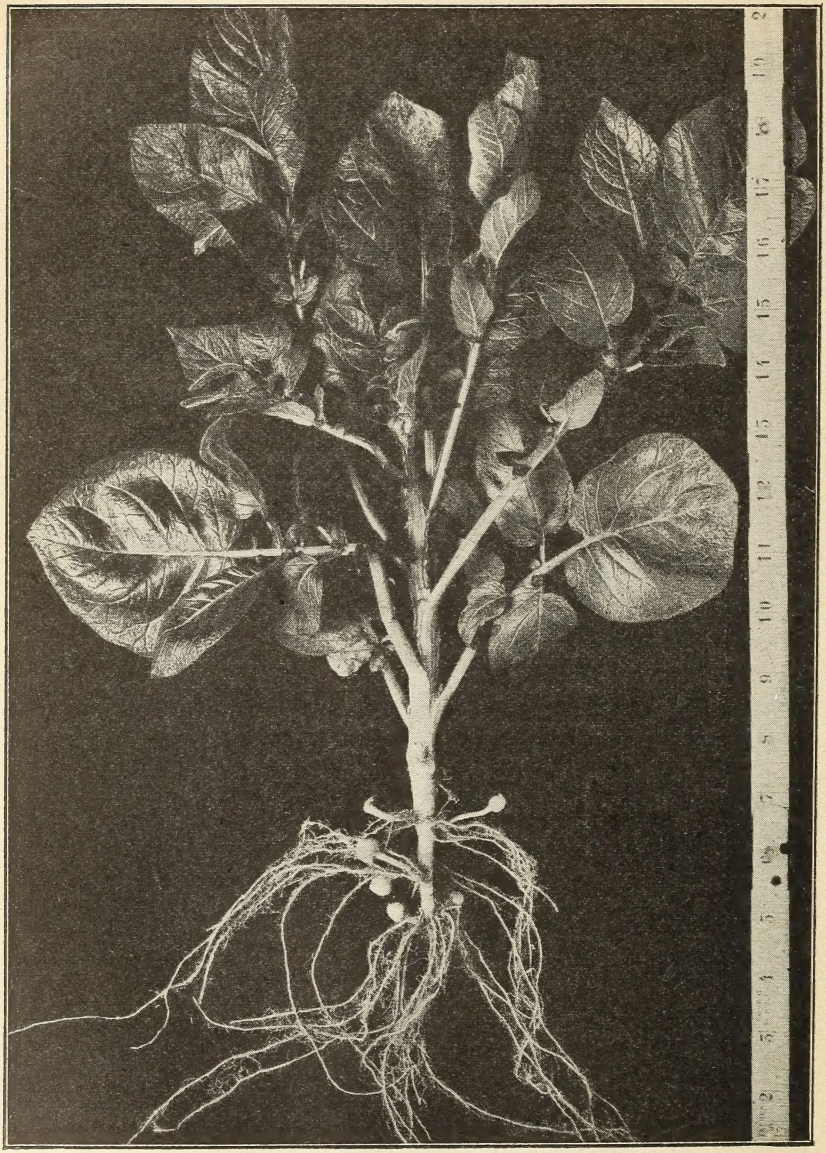

FIG. 5.—Plant of the Irish Cobbler variety of potato just after tuber formation had started.

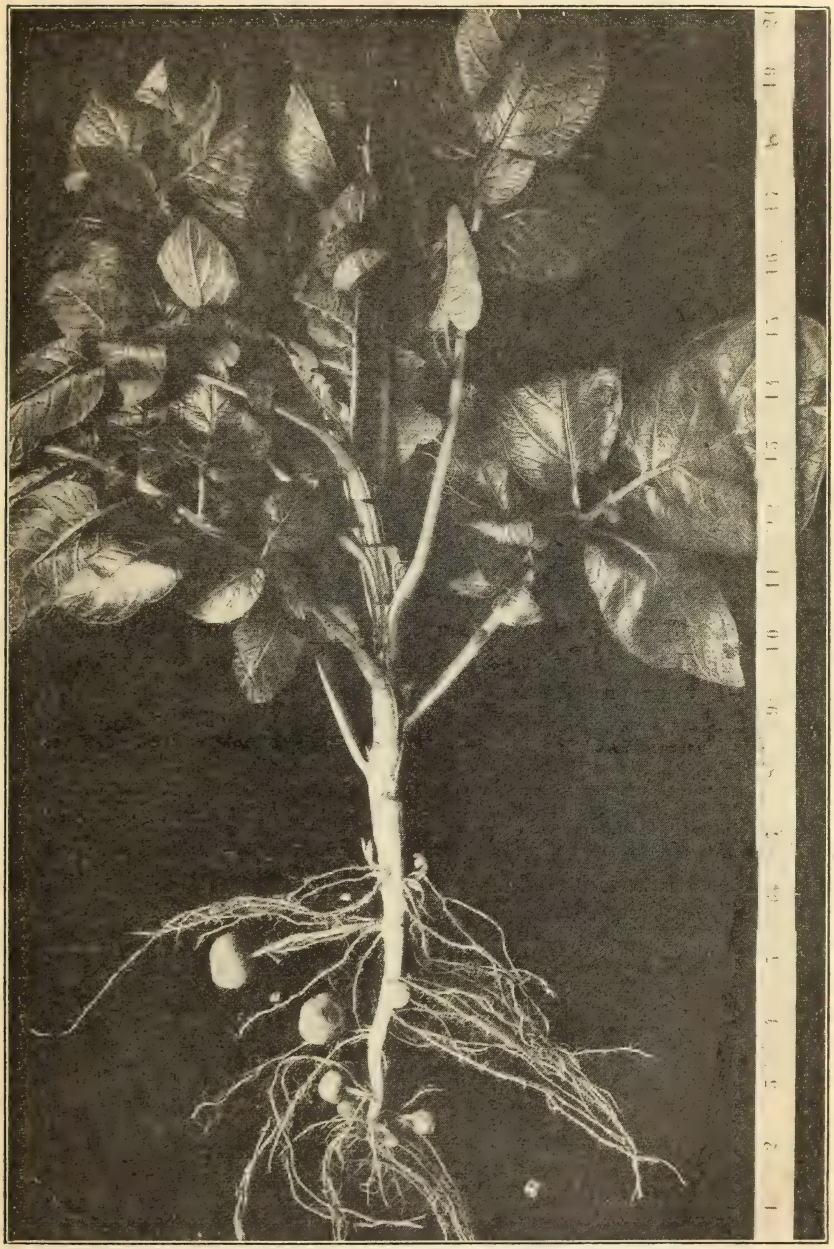

FIG. 6.—Plant of the Irish Cobbler variety of potato, showing later stage of tuber development.

These maximum rates were reached during the week ended August 31 in 1916 and September 6 in 1917, or after a growth period, from the time of planting, of 79 and 85 days, respectively. After these dates the gain per week gradually decreased. Since the first week in September marked the terminatiom of irrigation in both seasons, it is probable that the falling off in the rate of increase in weight per hill at such a comparatively early stage of the period of tuber development was due, in part at least, to the diminution of the moisture supply. There was no evidence of maturity of the plants at this time, the Rural New Yorker being a late variety which in this locality remains green and vigorous until killed by frost. In 1917 light frosts on the nights of October 7 and 8 killed the leaves of the plants on the experimental plats and a severe frost on October 11 completely killed the vines. The vines were also killed after the next to the last digging in 1916, so that the last increase recorded in each season represents the extent of tuber growth that had taken place after the death of the vines.

An inspection of Table II shows that there was a gradual spreading out of the frequency distributions toward the high values as the season advanced until the digging of October 4, after which no important changes occurred. One of the most striking features brought out in this table is the ununiform rate of growth in the tuber population. The last two samples of the season showed that between 11 and 12 per cent, or nearly one-eighth of the entire number of tubers, had failed to grow beyond the 25-gram class, the average weight of those remaining in this class being 8.2 grams. On the other hand, the data taken at each digging period show a rapid increase in the growth of the tubers of the larger sizes up to the time of the last harvest in September. These inequalities in growth are brought out more clearly in figure 7. It has previously been shown that practically all the tubers which grow to more than one-half inch in size set early in the season, probably at very nearly the same time; therefore, we must conclude that those which are small at the end of the season are of this relative size because of their failure to grow at a normal rate and not because they are of much more recent origin than the larger sizes.

In Table III, which gives the weight of the tubers in each of the 25-gram classes, the increases in size from week to week are shown by the gradual extension of the distribution and a shifting of the mode toward the higher classes up to October 4, after which there was little change. The failure of part of the small tubers to grow sufficiently to exceed in weight the limits of the 25-gram class, previously referred to, is further emphasized by this table, which shows very little change in the total weight of tubers in this class after September 20. The changes in the distribution with respect to weight resulting from tuber growth are shown in figure 8.

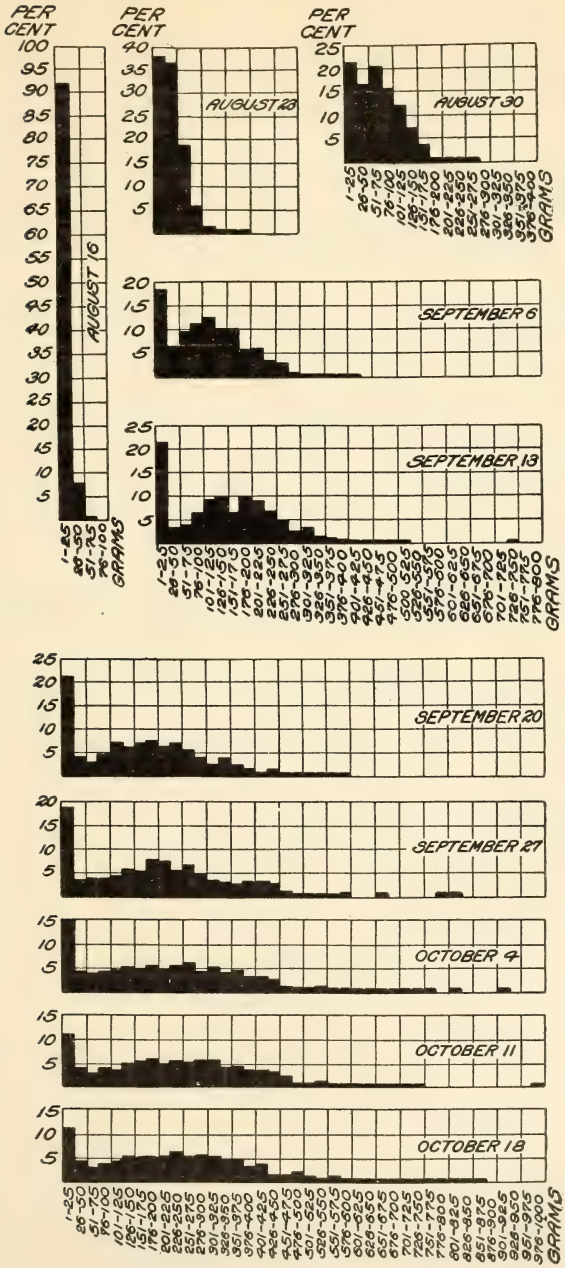

FIG. 7.—Diagram showing the percentage of tubers by number in classes, differing by 25 grams in weight, found in the tuber population of 200 hills at each date of digging.

TABLE II.—*Number and its percentage of Rural New Yorker potato tubers in each of the 25-gram classes, showing the changes in the distribution of the tuber population as the season advanced after planting on June 13, 1917, at Greeley, Colo.*

Weight limits.	Aug. 16.		Aug. 23.		Aug. 30.		Sept. 6.		Sept. 13.		Sept. 20.		Sept. 27.		Oct. 4.		Oct. 11.		Oct. 18.	
	Number.	*Per cent.*	*Number.*	*Per cent.*	*Number.*	*Per cent.*	*Number.*	*Per cent.*	*Number.*	*Per cent.*	*Number.*	*Per cent.*	*Number.*	*Per cent.*	*Number.*	*Per cent.*	*Number.*	*Per cent.*	*Number.*	*Per cent.*
Class No. 1, 1 to 25 grams	793	91.89	329	37.82	197	21.37	177	18.50	204	21.25	216	21.88	174	18.75	155	15.75	110	11.76	108	11.60
Class No. 2, 26 to 50 grams	68	7.88	314	36.09	153	16.59	62	6.48	28	2.92	42	4.26	26	2.80	42	4.27	39	4.17	39	4.19
Class No. 3, 51 to 75 grams	2	.23	161	18.51	188	20.39	91	9.51	33	3.44	31	3.14	35	3.77	41	4.17	27	2.89	27	2.90
Class No. 4, 76 to 100 grams			46	5.29	143	15.51	108	11.29	62	6.46	48	4.86	35	3.77	42	4.27	40	4.28	37	3.98
Class No. 5, 101 to 125 grams			17	1.95	115	12.47	120	12.54	87	9.06	71	7.19	37	3.99	43	4.37	37	3.96	40	4.30
Class No. 6, 126 to 150 grams			1	.11	68	7.38	99	10.34	93	9.69	62	6.28	50	5.39	51	5.18	49	5.24	53	5.69
Class No. 7, 151 to 175 grams			1	.11	30	3.25	98	10.24	64	6.67	72	7.29	47	5.06	47	4.78	52	5.56	43	4.62
Class No. 8, 176 to 200 grams			1	.11	10	1.08	61	6.37	89	9.27	73	7.40	71	7.65	55	5.59	57	6.10	44	4.73
Class No. 9, 201 to 225 grams					12	1.30	63	6.58	78	8.13	61	6.18	70	7.54	45	4.57	46	4.92	52	5.59
Class No. 10, 226 to 250 grams					5	.54	29	3.03	68	7.08	73	7.40	51	5.50	56	5.69	54	5.78	57	6.12
Class No. 11, 251 to 275 grams					1	.11	27	2.82	46	4.79	52	5.27	60	6.47	60	6.10	48	5.13	53	5.69
Class No. 12, 276 to 300 grams							8	.84	22	2.29	37	3.75	46	4.96	42	4.27	55	5.88	55	5.91
Class No. 13, 301 to 325 grams							4	.42	27	2.81	25	2.53	36	3.88	50	5.08	51	5.45	48	5.16
Class No. 14, 326 to 350 grams							4	.42	18	1.88	32	3.24	34	3.66	36	3.66	40	4.28	40	4.30
Class No. 15, 351 to 375 grams							3	.31	14	1.46	23	2.33	26	2.80	47	4.78	39	4.17	45	4.83
Class No. 16, 376 to 400 grams							1	.10	8	.83	19	1.93	28	3.02	29	2.95	33	3.53	28	3.01
Class No. 17, 401 to 425 grams							2	.21	4	.42	10	1.01	28	3.02	29	2.95	34	3.64	32	3.44
Class No. 18, 426 to 450 grams									7	.73	18	1.82	27	2.91	26	2.64	30	3.21	14	1.50
Class No. 19, 451 to 475 grams									3	.31	6	.61	10	1.08	15	1.52	24	2.57	13	1.40
Class No. 20, 476 to 500 grams									2	.21	4	.41	6	.65	12	1.22	12	1.28	22	2.36
Class No. 21, 501 to 525 grams									2	.21	6	.61	7	.75	9	.91	11	1.18	17	1.83

Class No. 22, 526 to 550 grams									0	0	2	.20	7	.75	13	1.32	15	1.60	13	1.40
Class No. 23, 551 to 575 grams									0	0	2	.20	7	.75	7	.71	7	.75	16	1.72
Class No. 24, 576 to 600 grams									0	0	2	.20	7	.75	6	.61	7	.75	5	.54
Class No. 25, 601 to 625 grams									0	0			0	0	3	.30	5	.53	7	.75
Class No. 26, 626 to 650 grams									0	0			0	0	6	.61	2	.21	2	.21
Class No. 27, 651 to 675 grams									0	0			1	.11	6	.61	4	.43	4	.43
Class No. 28, 676 to 700 grams									0	0			0	0	3	.30	2	.21	3	.32
Class No. 29, 701 to 725 grams									0	0			0	0	1	.10	3	.32	3	.32
Class No. 30, 726 to 750 grams									1	.10			0	0	1	.10	1	.11	6	.64
Class No. 31, 751 to 775 grams													0	0	4	.41	0	0	1	.11
Class No. 32, 776 to 800 grams													1	.11	0	0	0	0	1	.11
Class No. 33, 801 to 825 grams													1	.11	1	.10	0	0	1	.11
Class No. 34, 826 to 850 grams															0	0	0	0	1	.11
Class No. 35, 851 to 875 grams															0	0	0	0	1	.11
Class No. 36, 876 to 900 grams															0	0	0	0		
Class No. 37, 901 to 925 grams															1	.10	0	0		
Class No. 38, 926 to 950 grams																	0	0		
Class No. 39, 951 to 975 grams																	0	0		
Class No. 40, 976 to 1,000 grams																	1	.11		
Total	862	100	870	99.99	922	99.99	957	100	960	100.01	987	99.99	928	100	984	99.99	935	100	931	100.03

TABLE III.—*Weight and weight percentage of Rural New Yorker potato tubers in each of the 25-gram classes showing the changes in the distribution of the tuber population as the season advanced; after planting on June 13, 1917, at Greeley, Colo.*

Weight limits.	Aug. 16.		Aug. 23.		Aug. 30.		Sept. 6.		Sept. 13.		Sept. 20.		Sept. 27.		Oct. 4.		Oct. 11.		Oct. 18.	
	Grams.	*Per ct.*	*Grams.*	*Per ct.*	*Grams.*	*Per ct.*	*Grams.*	*Per ct.*	*Grams.*	*Per ct.*	*Grams.*	*Per ct.*	*Grams.*	*Per ct.*	*Grams.*	*Per ct.*	*Grams.*	*Per ct.*	*Grams.*	*Per ct.*
Class No. 1, 1 to 25 grams	8,590	78.59	3,460	10.99	1,520	2.40	1,025	0.96	1,140	0.81	1,325	0.82	980	0.53	910	0.42	900	0.41	890	0.39
Class No. 2, 26 to 50 grams	2,230	20.40	11,880	37.73	5,880	9.29	2,350	2.21	990	.71	1,580	.97	960	.52	1,565	.73	1,320	.60	1,460	.65
Class No. 3, 51 to 75 grams	110	1.01	9,830	31.22	11,620	18.35	5,785	5.44	2,030	1.45	1,945	1.20	2,180	1.18	2,520	1.17	1,620	.74	1,640	.73
Class No. 4, 76 to 100 grams			1,000	12.70	12,125	19.15	9,375	8.81	5,410	3.86	4,220	2.60	3,115	1.69	3,700	1.72	3,500	1.59	3,210	1.42
Class No. 5, 101 to 125 grams			1,840	5.84	12,625	19.94	13,315	12.51	9,705	6.93	7,970	4.92	4,080	2.21	4,670	2.17	4,150	1.89	4,380	1.94
Class No. 6, 126 to 150 grams			140	.44	9,180	14.50	13,500	12.69	12,530	8.95	8,460	5.22	6,700	3.63	6,880	3.19	6,650	3.02	7,110	3.15
Class No. 7, 151 to 175 grams			160	.51	4,720	7.46	15,760	14.81	10,330	7.38	11,650	7.18	7,520	4.07	7,540	3.50	8,200	3.73	6,860	3.04
Class No. 8, 176 to 200 grams			180	.57	1,765	2.79	11,255	10.58	16,345	11.67	13,700	8.45	13,030	7.05	10,080	4.68	10,500	4.77	8,080	3.58
Class No. 9, 201 to 225 grams					2,460	3.89	13,195	12.40	16,340	11.67	12,885	7.95	14,690	7.95	9,420	4.37	9,650	4.30	10,830	4.80
Class No. 10, 226 to 250 grams					1,160	1.83	6,730	6.33	15,960	11.40	17,150	10.58	11,960	6.47	13,170	6.11	12,620	5.74	13,340	5.92
Class No. 11, 251 to 275 grams					255	.40	6,980	6.56	11,900	8.50	13,500	8.33	15,590	8.44	15,420	7.16	12,430	5.65	13,700	6.08
Class No. 12, 276 to 300 grams							2,260	2.12	6,220	4.44	10,630	6.56	13,040	7.06	11,960	5.55	15,570	7.08	15,540	6.89
Class No. 13, 301 to 325 grams							1,225	1.15	8,350	5.96	7,700	4.75	11,250	6.09	15,340	7.12	15,790	7.18	14,700	6.52
Class No. 14, 326 to 350 grams							1,360	1.28	6,000	4.28	10,690	6.60	11,420	6.18	12,020	5.58	13,350	6.07	13,280	5.89
Class No. 15, 351 to 375 grams							1,075	1.01	5,040	3.60	8,240	5.08	9,370	5.07	16,860	7.83	13,950	6.34	16,110	7.15
Class No. 16, 376 to 400 grams							400	.38	3,040	2.17	7,360	4.54	10,820	5.85	11,120	5.16	12,680	5.76	10,750	4.77
Class No. 17, 401 to 425 grams							810	.76	1,620	1.16	4,140	2.55	11,450	6.20	11,800	5.48	13,770	6.26	13,020	5.78
Class No. 18, 426 to 450 grams									3,020	2.16	7,910	4.88	11,680	6.32	11,200	5.20	12,910	5.87	6,080	2.70
Class No. 19, 451 to 475 grams									1,400	1.00	2,760	1.70	4,570	2.47	6,890	3.20	11,040	5.02	5,930	2.63
Class No. 20, 476 to 500 grams									960	.69	1,930	1.19	2,880	1.56	5,760	2.67	5,810	2.64	10,590	4.70
Class No. 21, 501 to 525 grams									1,000	.71	3,060	1.89	3,540	1.92	4,560	2.12	5,540	2.52	8,550	3.79
Class No. 22, 526 to 550 grams									0	0	1,060	.65	3,720	2.01	6,900	3.20	7,980	3.63	6,870	3.05

Class No. 23, 551 to 575 grams									0	0	1,120	.69	3,910	2.12	3,890	1.81	3,880	1.76	8,940	3.97
Class No. 24, 576 to 600 grams									0	0	1,160	.72	4,080	2.21	3,470	1.61	4,120	1.87	2,880	1.28
Class No. 25, 601 to 625 grams									0	0			0	0	1,810	.84	3,020	1.37	4,200	1.86
Class No. 26, 626 to 650 grams									0	0			0	0	3,780	1.75	1,270	.57	1,280	.57
Class No. 27, 651 to 675 grams									0	0			670	.36	3,920	1.82	2,640	1.20	2,610	1.16
Class No. 28, 676 to 700 grams									0	0			0	0	2,070	.96	1,370	.62	2,060	.91
Class No. 29, 701 to 725 grams									0	0			0	0	710	.33	2,030	.91	2,120	.94
Class No. 30, 726 to 750 grams									725	.52			0	0	740	.34	740	.34	4,350	1.93
Class No. 31, 751 to 775 grams													0	0	3,010	140	0	0	760	.34
Class No. 32, 776 to 800 grams													790	.43	0	0	0	0	800	.35
Class No. 33, 801 to 825 grams													815	.44	820	.38	0	0	820	.36
Class No. 34, 826 to 850 grams															0	0	0	0	840	.37
Class No. 35, 851 to 875 grams															0	0	0	0	880	.39
Class No. 36, 876 to 900 grams															0	0	0	0		
Class No. 37, 901 to 925 grams															900	.42	0	0		
Class No. 38, 926 to 950 grams																	0	0		
Class No. 39, 951 to 975 grams																	0	0		
Class No. 40, 976 to 1,000 grams																	990	.45		
Total	10,930	100	31,490	100	63,310	100	106,400	100	140,055	100.02	162,145	100.02	184,810	100.03	215,405	99.99	219,990	99.99	225,460	100

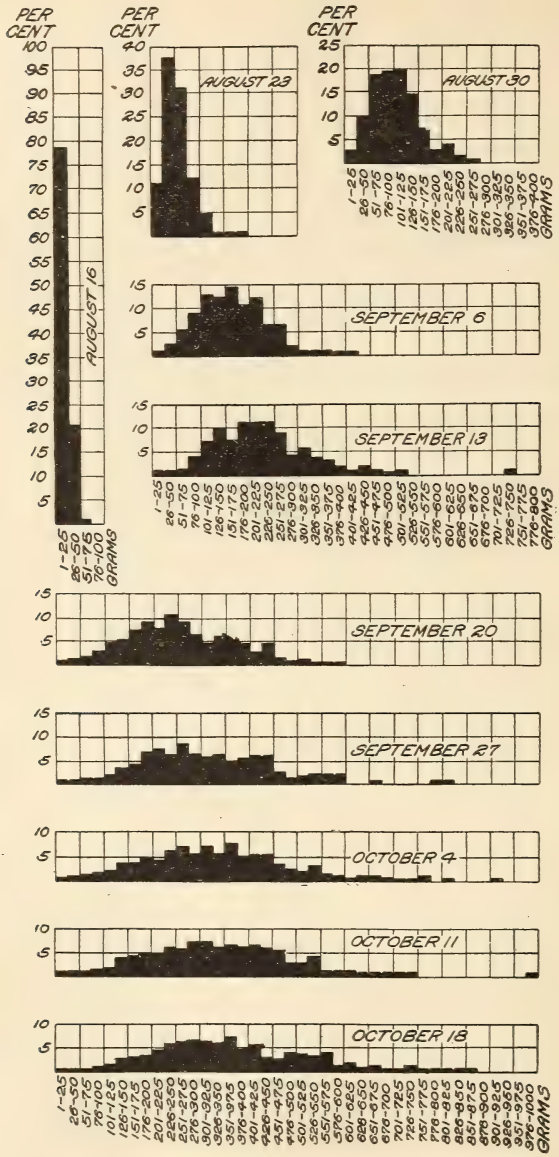

FIG. 8.—Diagram showing the percentage of tubers by classes, differing in weight by 25 grams, found in the tuber population of 200 hills at each date of digging.

LENGTH OF STOLON AND ITS POSITION ON THE STEM AS RELATED TO THE SIZE OF THE TUBER.

The experiments of 1917 had shown that there was great inequality in the rate of growth and consequently in the size of the tubers. To determine whether this condition was associated with the length of the stolon which bears the tuber and its position on the stem, 55 hills were dug in the fall of 1918, after the plants had reached maturity, and the stolons were measured and the tubers weighed. The variety used for this purpose was the Charles Downing. Early in the season, before the tubers had begun to set, the plants were thinned to a single stem, to avoid influences which might arise from the presence of several stems in the hill. All the measurements and weights obtained are shown in Table IV.

TABLE IV.—*Length of each stolon and weight of the tuber which it produced in 55 hills of Charles Downing potatoes grown at Greeley, Colo., in 1918.*

[The stolons in each hill are numbered in accordance with their relative position on the stem of the plant, beginning with the lowest.]

Plant and stolon.	Length of stolon.	Weight of tuber.
	Mm.	*Grams.*
Plant No. 1:		
Stolon 1	15	0
Stolon 2	54	247
Stolon 3	65	335
Plant No. 2:		
Stolon 1	50	0
Stolon 2	15	100
Stolon 3	85	340
Stolon 4	18	38
Stolon 5	86	38
Stolon 6	77	7
Plant No. 3:		
Stolon 1	12	115
Stolon 2	30	94
Stolon 3	42	67
Stolon 4	50	112
Plant No. 4:		
Stolon 1	5	325
Stolon 2	45	120
Plant No. 5:		
Stolon [a] 1	54	256
Stolon [a] 2	34	33
Plant No. 6:		
Stolon 1	2	197
Stolon 2	27	1
Stolon 3	155	175
Plant No. 7:		
Stolon 1	12	160
Stolon 2	35	150
Stolon 3	83	151
Plant No. 8:		
Stolon 1	4	125
Stolon 2	23	0
Stolon 3	17	27
Stolon 4	113	193
Plant No. 9:		
Stolon 1	115	103
Stolon 2	125	123
Stolon 3	75	23
Plant No. 10:		
Stolon 1	25	446
Stolon 2	18	103
Stolon 3	17	0
Stolon 4	30	0
Stolon 5	17	151
Plant No. 11:		
Stolon 1	27	88
Stolon 2	36	120
Stolon 3	30	70
Plant No. 12:		
Stolon 1	100	125
Stolon 2	124	115
Stolon 3	63	110
Stolon 4	147	226
Plant No. 13:		
Stolon 1	146	191
Stolon 2	148	138
Stolon 3	205	110
Stolon 4	130	13
Plant No. 14:		
Stolon 1	50	68
Stolon 2	110	150
Stolon 3	80	162
Plant No. 15:		
Stolon 1	34	264
Stolon 2	163	154
Plant No. 16:		
Stolon [a] 1	130	283
Stolon [a] 2	85	218
Stolon 3	186	46
Stolon 4	112	12
Plant No. 17:		
Stolon 1	91	122
Stolon 2	107	121
Stolon 3	90	143
Stolon 4	62	124
Plant No. 18:		
Stolon 1	22	199
Stolon 2	95	203
Plant No. 19:		
Stolon [a] 1	25	84
Stolon [a] 2	3	86
Stolon 3	70	142
Plant No. 20:		
Stolon 1	162	130
Stolon 2	58	0
Stolon 3	80	235
Plant No. 21:		
Stolon 1	34	241
Stolon 2	17	137
Plant No. 22:		
Stolon 1	77	383
Stolon [a] 2	305	119
Stolon [a] 3	170	258
Plant No. 23:		
Stolon 1	25	266
Stolon 2	23	114
Stolon 3	127	177

[a] Both stolons arising from the same node.

TABLE IV.—*Length of each stolon and weight of the tuber which it produced in 55 hills of Charles Downing potatoes grown at Greeley, Colo., in 1918*—Continued.

Plant and stolon.	Length of stolon.	Weight of tuber.
	Mm.	*Grams.*
Plant No. 24:		
Stolon 1	42	120
Stolon 2	18	169
Stolon 3	115	123
Plant No. 25:		
Stolon 1	32	202
Stolon 2	71	143
Plant No. 26:		
Stolon 1	110	44
Stolon 2	32	70
Stolon 3	46	134
Stolon 4	113	91
Stolon 5	126	56
Plant No. 27:		
Stolon 1	82	123
Stolon 2	58	277
Stolon 3	14	103
Stolon 4	160	16
Plant No. 28:		
Stolon 1	13	326
Stolon [a] 2	15	78
Stolon [a] 3	162	258
Plant No. 29:		
Stolon 1	25	95
Stolon 2	53	171
Stolon 3	95	107
Plant No. 30:		
Stolon [a] 1	19	174
Stolon [a] 2	176	103
Stolon 3	157	52
Stolon 4	120	116
Plant No. 31:		
Stolon 1	71	130
Stolon 2	180	93
Stolon 3	83	120
Stolon 4	175	80
Plant No. 32:		
Stolon 1	63	78
Stolon 2	28	222
Stolon 3	71	196
Stolon 4	135	33
Plant No. 33:		
Stolon 1	62	240
Stolon 2	82	125
Plant No. 34:		
Stolon 1	71	116
Stolon 2	66	175
Plant No. 35:		
Stolon 1	41	275
Stolon 2	119	12
Plant No. 36:		
Stolon 1	8	305
Stolon 2	32	220
Stolon 3	86	194
Plant No. 37:		
Stolon 1	53	140
Stolon 2	66	125
Stolon 3	88	92
Stolon 4	75	118
Plant No. 38:		
Stolon 1	100	408
Stolon 2	63	56
Stolon 3	281	184
Plant No. 39:		
Stolon 1	38	90
Stolon 2	87	71
Stolon 3	96	140
Stolon 4	120	88
Plant No. 40:		
Stolon 1	112	193
Stolon 2	30	63
Plant No. 41:		
Stolon 1	78	74
Stolon 2	63	130
Plant No. 42:		
Stolon 1	43	87
Stolon [a] 2	102	97
Stolon [a] 3	77	31
Stolon [a] 4	90	145
Stolon [a] 5	48	92
Stolon 6	141	47
Plant No. 43:		
Stolon 1	33	184
Stolon 2	86	303
Plant No. 44:		
Stolon 1	91	317
Stolon 2	100	158
Plant No. 45:		
Stolon 1	116	193
Stolon 2	66	210
Plant No. 46:		
Stolon 1	68	196
Stolon 2	90	183
Stolon 3	116	66
Plant No. 47:		
Stolon 1	102	139
Stolon 2	79	175
Plant No. 48:		
Stolon 1	77	337
Stolon 2	53	27
Stolon 3	122	114
Plant No. 49:		
Stolon 1	56	155
Stolon 2	57	280
Plant No. 50:		
Stolon 1	58	80
Stolon 2	63	124
Stolon 3	152	124
Stolon 4	48	115
Plant No. 51:		
Stolon 1	48	379
Stolon 2	51	150
Plant No. 52:		
Stolon 1	4	115
Stolon 2	92	170
Stolon 3	90	104
Plant No. 53:		
Stolon 1	81	49
Stolon 2	16	112
Stolon 3	37	141
Plant No. 54:		
Stolon 1	98	130
Stolon 2	2	240
Plant No. 55:		
Stolon 1	156	160
Stolon 2	32	380

[a] Both stolons arising from the same node.

To determine whether any relation exists between stolon length and tuber weight, the data shown in Table IV have been brought together in correlation form in Table V.

While there appears to be a slight trend toward negative correlation, the coefficient of —0.112 is but little more than twice the probable error; therefore it is to be regarded as having little signifi-

cance, so that the data present no conclusive evidence to show that the weight of the tuber is dependent upon the length of the stolon which bears it.

TABLE V.—*Correlation between the length of each stolon and the weight of the tuber which it produced in 55 hills of Charles Downing potatoes grown at Greeley, Colo., in 1918.*

[Coefficient of correlation, -0.112 ± 0.052.]

Length of stolons (mm.).	Weight of tubers (grams).																		Frequency.
	1 to 25	26 to 50	51 to 75	76 to 100	101 to 125	126 to 150	151 to 175	176 to 200	201 to 225	226 to 250	251 to 275	276 to 300	301 to 325	326 to 350	351 to 375	376 to 400	401 to 425	426 to 450	
1 to 25	....	2	....	5	7	1	4	2	....	1	1	....	2	1	....	....	....	1	27
26 to 50	1	1	5	5	5	3	....	1	3	1	2	....	....	....	....	2	....	....	29
51 to 75	1	1	1	2	5	6	3	2	1	2	1	2	....	1	....	....	....	....	28
76 to 100	1	3	2	1	8	4	5	2	2	1	....	....	2	2	....	1	1	....	35
101 to 125	2	1	1	3	7	2	....	3	....	....	....	....	....	....	....	....	....	....	19
126 to 150	1	2	1	....	....	1	....	2	....	1	....	1	....	....	....	....	....	....	9
151 to 175	1	....	1	1	1	1	3	....	....	....	2	....	....	....	....	....	....	....	10
176 to 200	....	1	....	1	1	....	....	....	....	....	....	....	....	....	....	....	....	....	3
201 to 225	....	....	....	....	1	....	....	....	....	....	....	....	....	....	....	....	....	....	1
226 to 250	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	0
251 to 275	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	0
276 to 300	....	....	....	....	....	....	....	1	....	....	....	....	....	....	....	....	....	....	1
301 to 325	....	....	....	....	1	....	....	....	....	....	....	....	....	....	....	....	....	....	1
Frequency	7	11	11	18	36	18	15	13	6	6	6	3	4	4	0	3	1	1	163

A further study of the data for the purpose of ascertaining whether the length of the stolon and the size of the tuber are associated with a definite position on the stem, included a grouping of the plants having two, three, and four stolons, respectively, using only those in which one tuber was produced at each node. The summarized results are shown in Table VI.

TABLE VI.—*Relation of the position of the stolon on the stem to the length of each stolon and the weight of the tuber which it produced, in 55 hills of Charles Downing potatoes grown at Greeley, Colo., in 1918.*

Position of the stolon.	Number of hills.	Length of the stolon.	Weight of the tuber.
Two stolons per hill:		*Mm.*	*Grams.*
Lower stolon	18	66.2	210.3
Upper stolon	18	68.0	175.4
Three stolons per hill:			
Lower stolon	14	45.4	179.1
Middle stolon	14	55.2	126.1
Upper stolon	14	106.6	127.9
Four stolons per hill:			
Lower stolon	10	71.4	119.4
Second stolon	10	89.1	138.0
Third stolon	10	90.4	120.5
Upper stolon	10	110.2	92.5

It will be seen that while the original tabulations (Table IV) show considerable fluctuation, the averages brought together in Table VI indicate very consistently a high degree of relationship between the position of the stolon and its length, the shortest stolons being

produced at the base of the stem, with a gradual increase in length in the upper positions. Since only one variety was included in this phase of the experiment, further studies with other varieties are necessary to determine the general applicability of these results.

With respect to the size of the tuber, the greatest average weight was produced by the lowest stolons in the 2-stolon and 3-stolon groups; while in the 4-stolon group the maximum production was in the second position, with a gradual decrease in the weight in the upper stolons. Larger numbers of observations, however, are needed to establish the laws governing these relationships.

SIZE AND CHARACTER OF SEED PIECES AS RELATED TO TUBER PRODUCTION.

Experiments were conducted to determine to what extent tuber production is influenced by the size of the seed piece; also to determine the relative influence of whole and cut seed. The tubers used for these studies consisted of 1, 2, 3, 4, 5, and 6 ounce sizes of the Rural New Yorker variety. One lot was planted whole, another cut in halves, and the remaining lot quartered. The hills were 16 inches apart in the row, with rows 36 inches apart. The series was duplicated and the work relating to the problem under discussion carried on for two years, 1916 and 1917.

Since the results of these experiments will be published in detail in another report, only a brief summary, which includes the averages of such data as bear directly on this question for the two years, will be given at this time (Tables VII and VIII).[3]

TABLE VII.—*Relation of the size and kind of seed piece to the number and weight of tubers per hill and per stem as shown in tests of the Rural New Yorker variety of potatoes grown at Greeley, Colo., in 1916 and 1917.*

Size of tubers.	Weight of seed piece planted (ounces).	Number of stems per hill.	Number of tubers.		Weight of tubers (grams).	
			Per hill.	Per stem.	Per hill.	Per stem.
Planted whole:						
1 ounce	1	1.76	4.25	2.41	712.72	404.80
2 ounces	2	2.60	6.31	2.42	876.55	336.74
3 ounces	3	3.22	7.18	2.23	886.23	274.85
4 ounces	4	3.72	7.96	2.14	952.92	255.86
5 ounces	5	4.51	9.22	2.04	986.59	218.65
6 ounces	6	5.03	10.11	2.01	1,030.31	204.70
Tubers cut in halves:						
2 ounces	1	1.81	3.99	2.20	668.61	368.89
3 ounces	1½	2.25	4.79	2.12	764.90	339.32
4 ounces	2	2.50	5.29	2.12	815.51	326.65
5 ounces	2½	2.63	5.61	2.13	785.78	298.45
6 ounces	3	3.05	6.28	2.06	836.54	274.14
Tubers cut in quarters:						
3 ounces	¾	1.49	3.35	2.25	663.84	444.84
4 ounces	1	1.63	3.63	2.23	673.25	413.20
5 ounces	1¼	1.85	3.94	2.13	724.84	390.91
6 ounces	1½	1.96	4.13	2.11	737.56	375.95

[3] The calculations of the data used in these tables are based on the total number of individuals for 1916 and 1917 rather than the average for the two years, so that they give the true averages for the entire period of the experiment.

A study of Table VII shows that both the number and the weight of tubers per hill varied directly with the size of the seed piece planted. There was also a corresponding increase in the number of stems per hill. If, however, we consider the stem rather than the hill as the unit for comparison, we find that the number of tubers which set per stem was affected in only a very small degree by the size of the seed piece, though the general trend was toward a slight decrease in the number of tubers produced as the size of the seed increased. The effect on the weight of the tubers per stem was much more pronounced, as there was a very consistent and well-defined decrease associated with increase in the size of the seed. It is apparent that the food supply was not sufficient to maintain the needs of the increased number of stems for maximum tuber production.

TABLE VIII.—*Relative influence of whole and cut seed on tuber production as shown by the results with different kinds of seed where seed pieces of the same weight were used in tests of the Rural New Yorker variety of potatoes grown at Greeley, Colo., in 1916 and 1917.*

Size and kind of seed.	Weight of seed piece planted (ounces).	Number of stems per hill.	Number of tubers.		Weight of tubers (grams).	
			Per hill.	Per stem.	Per hill.	Per stem.
1 ounce, whole	1	1.76	4.25	2.41	712.72	404.80
2 ounce, halved		1.81	3.99	2.20	668.61	368.89
4 ounce, quartered		1.63	3.63	2.23	673.25	413.20
2 ounce, whole	2	2.60	6.31	2.42	876.55	336.74
4 ounce, halved		2.50	5.29	2.12	815.51	326.65
3 ounce, whole	3	3.22	7.18	2.23	886.23	274.85
6 ounce, halved		3.05	6.28	2.06	836.54	274.14
3 ounce, halved	1½	2.25	4.79	2.12	764.90	339.32
6 ounce, quartered		1.96	4.13	2.11	737.56	375.95

Comparisons of the results obtained from whole and cut seed recorded in Table VIII show a slightly larger number and, with one exception, a larger weight of tubers per stem where whole seed was used.

RELATION OF VARIETY TO TUBER PRODUCTION.

It is a matter of common observation that the tuber-producing ability of different varieties varies considerably with respect to the number and the weight of tubers per hill as well as other characteristics. This is brought out very clearly in the curves shown in figures 9 and 10. The data on which these are based were obtained in 1915 from 500 hills each of the Pearl and Rural New Yorker varieties taken from adjacent plats which were grown under conditions as nearly identical as possible.

A study of the curves for the number of tubers (fig. 9) shows an entirely different distribution for the two varieties. In the Rural

New Yorker there was a very decided grouping around the model class, 22.2 per cent of the entire number of hills falling in this class and 61.2 per cent in the 3, 4, and 5 tuber classes. In the Pearl there was a much wider range of variability, with a considerable number

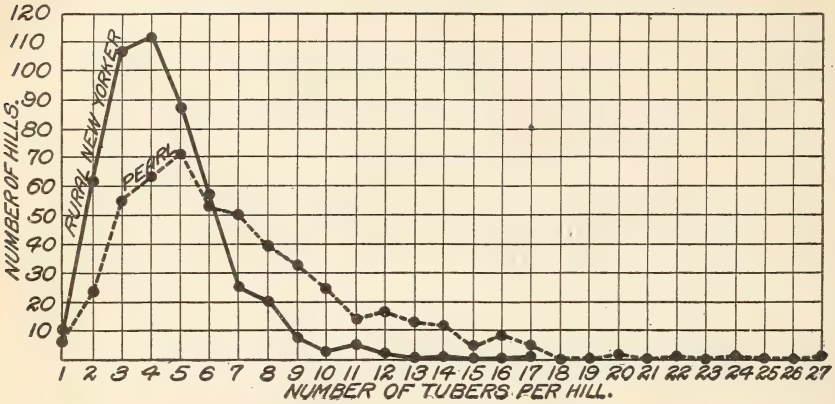

FIG. 9.—Diagram showing the number of tubers per hill produced in 500 hills of Rural New Yorker (average, 4.5) and 500 hills of Pearl (average, 6.9).

of the individuals in the intermediate classes. The average hill production of this variety was 2.4 tubers greater than that of the Rural New Yorker.

The curves for weight of tubers per hill (fig. 10) show that there was much greater uniformity in production in the Rural New Yorker.

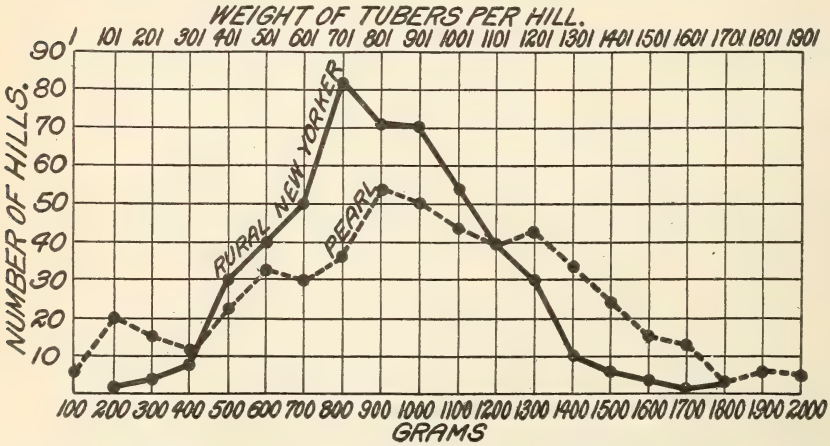

FIG. 10.—Diagram showing the weight of tubers per hill produced in 500 hills of Rural New Yorker (average, 860.7 grams) and 500 hills of Pearl (average, 944 grams).

The Pearl, however, produced the larger average yield, the weight per hill exceeding that of the Rural New Yorker by 83.3 grams.

A further comparison of the behavior of different varieties of potatoes under varying treatment respecting irrigation is shown in Table

IX. particularly in the averages of the data obtained in 1917. The variation in tuber production according to variety is there clearly shown, the number of tubers per hill ranging from 3.8 in the Rural New Yorker to 7.1 in the Charles Downing. The lowest average weights per hill were produced by the two early varieties, Triumph and Early Ohio, and the highest by the Pearl, which is a late variety.

TABLE IX.—*Effect of irrigation on the average number and the average weight of the tubers of different varieties of potatoes grown at Greeley, Colo., in 1917 and 1918.*

Year and variety.	Number of tubers per hill.					Weight of tubers per hill (grams).				
	No irrigation.	First irrigation after tubers had begun to set.	Irrigation started before tubers had begun to set.		Average.	No irrigation.	First irrigation after tubers had begun to set.	Irrigation started before tubers had begun to set.		Average.
			Medium number of irrigations.	Many irrigations.				Medium number of irrigations.	Many irrigations.	
Experiments in 1917:										
Triumph	4.4	3.9	7.8	5.9	5.5	459.8	697.2	1,060.7	702.0	729.9
Early Ohio	3.2	4.2	6.3	6.7	4.8	413.0	712.3	928.3	1,145.0	730.6
Charles Downing	5.1	7.1	9.4	6.6	7.1	446.3	830.3	1,005.7	811.3	773.4
Pearl	5.3	5.1	6.2	7.7	6.1	528.0	887.8	1,036.3	1,137.7	897.5
Rural New Yorker	3.5	3.2	4.3	4.2	3.8	533.5	759.8	876.7	884.7	763.7
Russet Burbank	3.6	4.2	6.5	6.2	5.1	425.7	826.7	974.3	868.3	773.8
Peachblow	4.5	5.6	6.9	9.0	6.5	433.7	867.0	991.3	926.7	804.7
Average	4.2	4.8	6.8	6.6	.....	462.9	797.3	981.9	925.1	.....
Experiments in 1918:										
Triumph	3.6	3.1	3.1	3.6	3.4	269.0	266.3	317.5	365.1	304.5
Late Ohio	3.3	3.1	3.0	3.6	3.5	374.2	482.2	675.9	654.1	546.6
Charles Downing	5.1	5.0	6.5	6.6	5.8	342.9	420.5	589.7	655.9	502.3
Pearl	3.3	3.5	3.3	3.7	3.5	399.2	490.3	610.1	676.3	544.0
Rural New Yorker	3.4	3.8	4.3	4.0	3.9	324.3	475.4	645.5	652.3	524.4
Average	3.7	3.7	4.2	4.3	.....	341.9	426.9	567.7	600.7	.....

CHARACTER OF SOIL AS RELATED TO TUBER PRODUCTION.

In 1918 experiments were conducted for the purpose of determining to what extent, if any, tuber production is influenced by the type of soil. Two varieties, the Triumph and the Rural New Yorker, were used for these studies. The seed for each variety, which was obtained from a single source, was divided into three lots. One lot of each variety was grown on the farm of Mr. W. M. Wilson,[4] on a very heavy clay soil classified as "Billings clay loam (3);" a second lot was grown on the experiment station farm on a clay-loam soil designated as "Fort Collins loam (3);" the remaining lot was grown on the farm of Mr. W. R. McClellan[4] on a sandy loam known as "Colorado fine sandy loam (3)."

The crops on all plats were grown under practical field conditions, the cultivation and irrigation practices following the methods in gen-

[4] The writer is indebted to W. M. Wilson and W. R. McClellan for their cooperation in growing the experimental crops produced on the heavy clay and fine sandy loam, respectively.

eral use on the soils in question. After the crop had reached maturity 400 hills of each crop were dug, the tubers counted, and the weight for each hill obtained. The results are given in Table X.

TABLE X.—*Relation of soil type to the number and the weight of tubers as shown in tests of two varieties of potatoes grown under field conditions near Greeley, Colo., in 1918.*

Character of the soil.	Triumph variety.			Rural New Yorker variety.		
	Number of tubers per hill.	Weight of tubers (grams).		Number of tubers per hill.	Weight of tubers (grams).	
		Per hill.	Average.		Per hill.	Average.
Heavy clay	3.1	194.6	62.0	3.0	376.7	125.3
Clay loam	4.2	387.2	93.3	4.9	663.7	136.5
Fine sandy loam	5.9	489.4	83.3	6.3	1,033.5	162.8

The lowest production of tubers with respect to both number and weight per hill was on the heaviest soil, while the highest numbers and yields were produced on the lightest soil, indicating a tendency toward an increase in the productivity of the plant as the character of the soil changes toward the lighter types. Since these results cover only a single season, it is possible that the relationships found to exist in this experiment might be modified somewhat under different climatic conditions as well as by differences in the relative state of productivity of the different soil types. The data do, however, show very conclusively the influence of the character of the soil on tuber production.

TIME AND NUMBER OF IRRIGATIONS AS RELATED TO TUBER PRODUCTION.

The material used for the study of the relation of irrigation methods to tuber production consisted in 1917 of one row each of seven varieties divided into four sections. The first received no irrigation. On the second section irrigation was not begun until after tuber formation was well started. On the third and fourth sections the first applications of water were before tuber formation had started. On the fourth section the number of irrigations was somewhat in excess of what would be considered the optimum in commercial field practice. At the time of harvest 30 hills were dug from each section of each row (except in the fourth section of the Early Ohio, where disease reduced the number of healthy hills to 10), and the hills were weighed and the tubers counted.

In 1918 practically the same plan was followed, except that the number of varieties was reduced to five, and each section of each variety consisted of two full rows of approximately 200 hills each. The effects of the early irrigations in this season were to some extent counterbalanced by a relatively large rainfall between the periods of germination and the beginning of tuber formation.

The dates of irrigation in both 1917 and 1918 are shown in Table XI. The number and the weights of tubers have already been shown (Table IX). Considering the averages of all the varieties for each year, it is found that in both seasons the early application of water, before tuber formation had started, resulted in an increase in the number of tubers as well as in the weight per hill. Starting irrigation late in the season materially increased the weight over that produced on the nonirrigated plats. On the other hand, very little difference is shown in the number of tubers per hill produced under the two conditions. In 1917 a slight increase was indicated, but the small number of individuals involved raises the question whether so small a difference may not be due to so-called experimental error. Where irrigation was started before the tubers had begun to form, increasing the number of irrigations did not increase the number of tubers. In 1918 one extra irrigation increased the weight of tubers 33 grams per hill, while in 1917 four extra irrigations resulted in a decrease in weight. Apparently the quantity of water applied in this case was in excess of the optimum requirements of the plants. The results in general, while not of sufficient extent to warrant final conclusions, indicate that each application of water, at almost any period in the growth of the plant, provided excessive quantities are not used, may be expected to produce an increase in the weight of the crop, but that little or no increase in the number of tubers is likely to result from irrigation after tuber formation is well started.

TABLE XI.—*Dates of irrigation in 1917 and 1918 as related to the production of potato tubers of different varieties grown at Greeley, Colo., in 1917 and 1918.*

Treatment.	Experiments in 1917.				Experiments in 1918.		
	June.	July.	August.	September.	July.	August.	September.
First irrigation after tubers had begun to set	.....	.....	14, 19, and 31.	7	.....	21	4
Irrigation begun early, medium number	.....	27	...do...	7	6	8, 15, and 30.	4
Irrigation begun early, many irrigations	21	3, 15, 21, and 27.	...do...	7	6	8, 15, 25, and 30.	4

SUMMARY.

The time of the beginning of tuber formation was found to coincide very closely with the end of the period of flower-bud development.

The statistical studies of tubers at 1-week intervals showed that the greater part of those which grew to exceed half an inch in diameter were formed at the beginning of the period of tuber development

The maximum rate of growth of the tubers was found to occur about the last of August or first of September, which was approxi-

mately 80 days after planting. At this time nearly one-third of the total period of tuber development had been completed.

The differences in the sizes of tubers in the individual hill are attributed largely to the unequal rate of growth rather than to differences in the age of the tubers.

A small increase in the weight of tubers was found to occur after the vines had been killed by frost.

The weight of the tuber does not appear to be correlated with the length of the stolon upon which it is produced.

The average data show a tendency toward a decrease in the size of the tuber on the upper stolons, though the individual plants showed considerable diversity in this respect.

The number and the weights of tubers per hill were found to be influenced by the size and the kind of the seed piece planted.

Well-defined differences were found in the tuber-producing capacity of different varieties when grown under similar conditions.

The experiments on different types of soil showed that a close relationship exists between the character of the soil and the number and the weight of tubers. The largest numbers and weights were produced on the lighter types of soil.

The irrigation experiments, while not carried to a final conclusion, indicated that the application of water before tuber formation had begun increased the number of tubers. Increasing the number of irrigations appears to have had little effect on the number of tubers. The weight per hill, however, was increased by each additional irrigation except where the applications were too frequent.

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